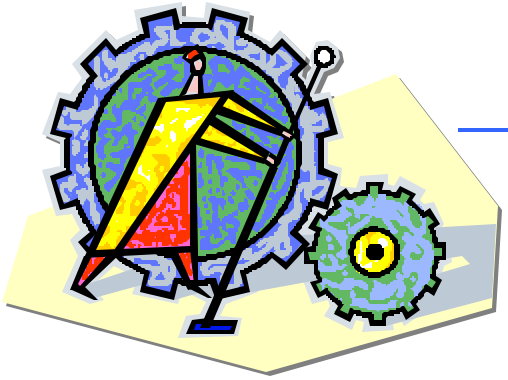

#3658

SIMPLE MACHINES:
LEVER, WHEEL, AXLE, AND PULLEY

Grade Levels: 6-12
15 minutes
CAMBRIDGE EDUCATIONAL 1998

DESCRIPTION

What is a simple machine? A device that can make work easier, make work faster, or change direction of force. Uses animated and real examples to illustrate three of the six simple machines: the lever, wheel and axle, and pulley. Defines terms associated with each, and gives several everyday examples. Summarizes content at the end.

ACADEMIC STANDARDS

Subject Area: Science

- Standard: Understands motion and the principles that explain it
  - Benchmark: Knows the relationship between the strength of a force and its effect on an object (e.g., the greater the force, the greater the change in motion; the more massive the object, the smaller the effect of a given force)
  - Benchmark: Knows that when a force is applied to an object, the object either speeds up, slows down, or goes in a different direction

Subject Area: Historical Understanding

- Standard: Understands and knows how to analyze chronological relationships and patterns
  - Benchmark: Knows how to construct time lines in significant historical developments that mark at evenly spaced intervals the years, decades, and centuries
  - Benchmark: Knows how to identify patterns of change and continuity in the history of the community, state, and nation, and in the lives of people of various cultures from times long ago until today

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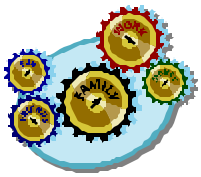
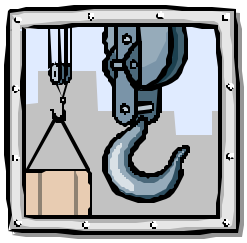
AFTER SHOWING



Applications and Activities

1. Create a student-designed bulletin board using magazine pictures of objects that are levers, pulleys, and wheel and axles.
2. Conduct an experiment to find out where to push on a lever to get the best lift. You will need a ruler, pencil, and two large coins. Follow this procedure:
   a. Put the pencil under the ruler and place a coin on one end.
   b. Drop the second coin from a height of 30 cm so it hits the ruler at about the 7 mark. Notice how high the coin jumps in the air.
   c. Repeat the coin drop but drop it at the end of the ruler from the same height.
3. After completing the coin drop experiment, answer the following:
   a. Where would you drop your coin for optimal height?
   b. Why are the trial results different?
   c. What would happen if you put an object with a large diameter than the pencil under the ruler? Try this experiment.
   d. What would happen if you used a meter stick instead of a ruler? Experiment.
   e. Move the pencil to different locations under the ruler; repeat the experiment. Were your results different or the same?



SUMMARY

THE BASICS OF SIMPLE MACHINES

Machines help us do work. Work is done when a force moves something in the direction of that force. In order for something to be a machine, it must do one of the following things: make work easier, make work faster, or change the direction of a force. This is the equation for work:

Work = Force x Distance

Machines make work easier by decreasing the amount of force needed to complete a task, but machines can not create energy. If a machine cuts the force needed to move something in half, the machine will have to move twice as far. The benefits of this relationship become obvious if you are asked, "Would you rather move 500 pounds 1 foot or five pounds 100 feet?" The same amount of work is completed in each example, but the latter would definitely be easier.

There are six simple machines: the inclined plane, wedge, screw, lever, wheel and axle, and pulley. These machines are used by themselves or in combination in all machines. If more than one simple machine is used in a machine, it is called a compound machine. This includes machines that use two or more of the same kind of simple machine.

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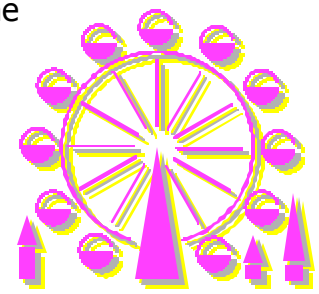
A lever has two parts—the lever itself which is a bar or rod, and the fulcrum that is used to support the lever. Levers have two primary uses. One is to increase a force, usually in the form of lifting or prying. The other is to increase speed. The lever can translate small movements on one end into longer faster movements in the other end. There are three classes of levers. The class of lever is determined by the position of the fulcrum, effort (the force applied to the lever), and the load (force acting against the lever).

Class 1: Fulcrum between effort and load (see-saw)
Class 2: Load between fulcrum and effort (bottle opener)
Class 3: Effort between load and fulcrum (broom)

A wheel and axle works like a rotating lever. The fulcrum is located at the center of the wheel and axle, and the wheel and axle rotate around it. The wheel doesn't need to be round to rotate; it just needs to be able to move in a circle. The effort may be applied to either the wheel or the axle, depending on the use of the machine. If the wheel and axle is being used to increase an effort, like when using a lug wrench to remove a tire, the effort is applied to the wheel and the load acts on the axle. If the goal is to increase the speed, like making the blades of a fan move more quickly, the load is applied to the axle and the blades act as the wheel.



A pulley is a wheel attached to a support, with a rope strung around it. A single pulley can be used to change the direction of a force, like pulling down a flag cord to make a flag go up the pole. Pulleys used in combination are called a "block and tackle." A block and tackle setup can help make work easier, like when a big crane is used to lift something heavy. Pulleys used in combination will always be used in sets of two.

REAL-WORLD EXAMPLES

It is no secret that students learn better if they get the opportunity to see a theory applied to a real-world example. One of the great things about simple machines is that they are everywhere. Have your students examine the room for simple machines. Be sure and recognize compound machines whenever possible. Here are a few machines that can probably be found in your classroom to get you started:

pencil sharpener–wheel and axle (handle) and wedge (cuts pencil)
door knob–wheel and axle
clock (analog)–wheel and axle (gears and hands)
fan–wheel and axle
tuning knobs on TV–wheel and axle

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CALCULATIONS

To find out how much a machine helps complete a task, we need to calculate the mechanical advantage. The mechanical advantage is the factor that a machine increases the force by. If a machine enables us to lift a 10-pound weight with one pound of force, it has increased the force output by the factor of ten. That means that the mechanical advantage is ten.

In order to determine the mechanical advantage of a lever, divide the effort arm (from the effort to the fulcrum) by load arm (from the load to the fulcrum). Be sure you are only measuring where the effort and load contact the lever. If part of the lever extends past the effort or load, it provides no extra mechanical advantage.

$$\text{Lever M.A.} = \frac{\text{Effort Arm}}{\text{Load Arm}}$$

A wheel and axle is related to the lever. The effort arm of the lever matches the wheel, while the load arm matches the axle. To determine the mechanical advantage of the wheel and axle, all you have to do is divide the radius of the wheel by the radius of the axle.

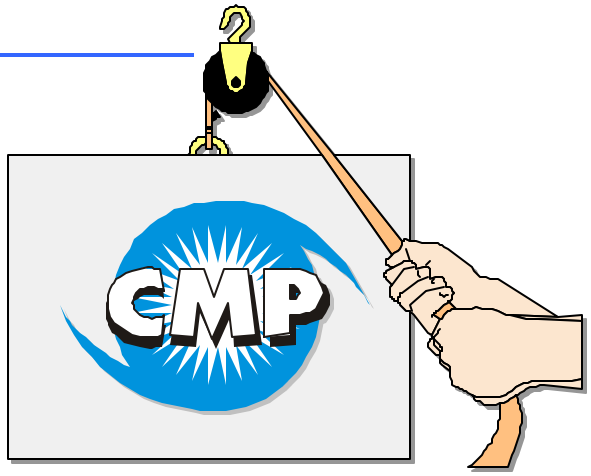
$$\text{Wheel and Axle M.A.} = \frac{\text{Wheel Radius}}{\text{Axle Radius}}$$

When using a single pulley, the effort and load forces are equal. That means that the mechanical advantage of a single pulley is one. When using pulleys together, like a block and tackle system, the mechanical advantage is the same as the number of pulleys used. If a crane uses 10 pulleys to help lift a load, the mechanical advantage is ten. In a multiple pulley setup, pulleys will always be used in sets of two.

RELATED RESOURCES

Captioned Media Program

- Pulleys #2001
- Simple Machines: Inclined Plane, Wedge and Screw #3657



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World Wide Web

The following Web sites complement the contents of this guide; they were selected by professionals who have experience in teaching deaf and hard of hearing students. Every effort was made to select accurate, educationally relevant, and "kid-safe" sites. However, teachers should preview them before use. The U.S. Department of Education, the National Association of the Deaf, and the Captioned Media Program do not endorse the sites and are not responsible for their content.

- **SIMPLE MACHINES**

http://sln.fi.edu/qa97/spotlight3/spotlight3.html

Print information from the Franklin Institute written for (strong readers) children. Covers the basics with text and simple graphics. Great links to additional information.

- **SMITHSONIAN: INVENTORS AND INNOVATION**

http://www.si.edu/resource/faq/nmah/invent.htm

Offers a list of links that provide a short history of famous inventors and inventions. Among others, the telegraph, the light bulb, and the computer are featured.

- **RUBE GOLDBERG MACHINE CONTEST**

http://www.rubegoldberg.com/contest.htm

Information on kid contests to create machines using the famous Pulitzer Prize winner's wacky and wonderful 20-step method.

- **THE HISTORY OF INVENTION**

http://www.cbc4kids.ca/general/the-lab/history-of-invention/default.html

Smith College's time line of inventions through history. Click and scroll. Text and pictures.